SOME NOTES

ON THE

CONSOLIDATION OF TWO SYSTEMS OF ELECTRIC SUPPLY

. . . BY . . .

A. A. DION, M. A. I. E. E.,

OTTAWA, ONT.

HD9685
C33
O82
1900

THE march of electrical progress has been so rapid within the last few years, such marked advances have been made in the methods of supply and distribution of electrical energy for light and power, that central stations, which six or seven years ago were looked upon as the embodiment of the best and latest practice, are already handicapped in the race for wealth, in view of the many improvements which have been made since that time.

2. The constant and rapid increase in the use of electricity in cities has correspondingly increased the difficulties of distribution at constant potential, and new systems have had to be devised to meet the new conditions. Electric supply companies, whose stations were equipped when distribution at one thousand volts seemed like tempting providence, and small generator units were the rule rather than the exception, now find it impossible to adopt more economical systems of distribution without undue sacrifice of apparatus, and must confine their efforts towards the improvement of their services to changes within the limits of existing pressures.

3. The amalgamation of rival electrical interests, which is not infrequent in these times, brings up another and more difficult problem, that of consolidating various and oftentimes conflicting elements to form a single and uniform system. To do this without throwing any apparatus out of service was the task that the writer was lately called upon to undertake.

4. He does not claim originality for any of the features of the plan adopted, but simply states how it was done, in a particular case, believing that in furnishing each other information regarding work done in our respective fields of action, we best carry out the objects of this Association, and he trusts that some of the members may be benefitted by the discussion which this paper may bring out, if not by the paper itself.

5. The amalgamation above referred to comprised three electric light companies, namely, "The Ottawa Electric Light Company," "The Chaudiere Electric Light and Power Company," and "The Standard Electric Company of Ottawa."

THE OTTAWA ELECTRIC LIGHT COMPANY.

6. This was the oldest company, it having commenced business in 1881, and its operations were confined to arc lighting. It owned a substantial stone power house. The motive power was water, and was transmitted through four vertical turbines operating under a head of sixteen feet. The electrical equipment consisted of eighteen T. H. ten Ampere generators manufactured by the Royal Co. of Montreal, supplying 325 lights for lighting the streets of the city and 95 lights for private lighting. This company also owned a small workshop for armature and arc lamp repairs.

THE CHAUDIERE ELECTRIC LIGHT AND POWER COMPANY.

7. This company was the next in point of age, it having commenced business in 1887. Its business was confined to incandescent lighting and supplying power for motors. Its first plant was a multiple series system, using the well known U. S. double magnet generators of 25 amperes and 550 volts. The lighting was limited to stores and other public places ; five lights were run in series. Each light pendent consisted of two lamps, one above the other. The lower lamp alone normally burned. When, however, it burned out, an electro-magnetic device, contained in the socket, instantly brought the upper lamp in circuit, thereby preserving the continuity thereof.

8. These machines were replaced in 1889 by the Alternating Current Converter system, but were used later for other purposes. The first installation of the latter system consisted of two Westinghouse smooth core alternators of 750 lights capacity each, that were separately excited by small machines of the U.S. type. At the time of amalgamation this company had installed 27,000 incandescent lights and 42-500 volt motors ranging from one and one-half to 20 h. p. and aggregating 320 h. p.

9. This company occupied three power houses, which, for the purpose of this paper we will designate as "a," "b" and "c."

10. "a" was the original power house, and was operated by water. It contained eight 750 light Westinghouse alternators separately excited. From this station eleven pairs of lighting feeders ran to various parts of the city. The switchboard was equipped with indicating instruments of the Westinghouse pendulum type,—one ampere meter for each pair of feeders and one voltmeter for each alternator—Westinghouse compensators, Wurtz non-arcing lightning arresters and a large number of double-throw switches by means of which the feeders and generators were made interchangeable. Some of the longer circuits were supplied with regulators or "boosters."

11. "b" was the next power house to be occupied. It was also a water power station and was built when the daily loads outgrew the capacity of "a." The electrical equipment of "b" consisted of a 1,500 light Westinghouse alternator with smooth core armature and a 120 K. W. alternator with toothed core armature, both separately excited, and a 75 K. W. 500 volt U.S. direct current generator of the upright type. The alternators were separately connected by wires to the switchboard in station "a," some four hundred feet away, and the D. C. generator supplied the motor circuits, two in number, which ran from this station.

12. "c" was a steam power station which had been built in 1893 as an auxiliary, made necessary, on account of periodical diminution of the water power through anchor ice and other causes. No place could be found for the steam plant on the premises of the other stations, therefore it had to be erected some distance away on a water course where an abundant supply of water was available for condensing purposes. Additional electrical equipment had therefore to be provided for this station.

The building was a one story brick structure with stone foundation 85 ft. by 130 ft. It contained six return tube boilers 14 ft. by 60 inches and a pair of tandem compound condensing Wheelock engines, rated at six hundred horse power each. These engines were belted through clutch pulleys to a six inch shaft running through the building. Two Westinghouse alternators of 240 K. W. capacity each with toothed armatures were belted to the shaft also through clutch pulleys. They were separately connected by wires to the switchboard in station "a," some two thousand feet distant. In this case pressure wires were run back from the switchboard to the voltmeter in the steam station. Floor and shaft space and stone piers were provided for additional generators.

13. The alternators of this company were run at about 1,100 volts, except those in the steam station, which, owing to their distance from the switchboard, etc., were run at nearly 1,200 volts, when fully loaded, that being their rated capacity. The frequency in every case was about 133 cycles per second. Westinghouse converters—1,000 50 volt—were used, mostly small ones, 1,000 to 2,000 watts and a few of 4,000 watts and 5,000 watts. Over three-quarters of the current output was supplied through meters, the Schallenberger being used exclusively. This company also had a small workshop for re-winding armatures and field coils.

THE STANDARD ELECTRIC COMPANY OF OTTAWA.

14. This was the junior company, it having commenced business in 1891. It could thus profit by the experience of others, and it had made provision for considerable extensions of the original plant. It occupied a substantial two storey building with a hydraulic plant consisting of four 66 inch turbines operating under a head of twenty-two feet with shafting, clutch pulleys, etc., which made each turbine capable of running the whole station or any part of it. This station contained six separately excited alternators of The Royal Company's manufacture, i. e., one of 5,000 lights capacity, one of 2,000 lights capacity, and four of 1,500 lights each, and four sixty horsepower direct current compound wound generators, also manufactured by The Royal Company. The direct current machines were used for the supply of power for motors; two of them were run in series operating a one hundred horsepower 500 volt motor running an entire flour mill day and night. Another was used to supply 33 250 volt motors ranging from ¼ h. p. to 20 h. p., and aggregating 105 h. p. The other was held in reserve.

14. The alternators were run at a frequency of about 133 cycles per second. The lighting switchboard was equipped with T. H. measuring instruments and plug panels which made the ten lighting circuits and the six alternators interchangeable. The voltmeters were connected with the centres of distribution by pressure wires, the distribution being made through T. H. and "Royal" transformers.—1040 52 volts—52 volt lamps and T. H. wattmeters were used throughout the system.

15. There were 18,000 incandescent lights installed.

CONSOLIDATION.

16. The plans adopted for consolidating these several systems have not all been carried out at this time. The work is being done in a gradual manner in order to cause no commotion among subscribers, but for the purpose of this paper we will assume that this work has been completed and speak of things as they will be. As a first step towards carrying out the proposed changes, the small work shops above mentioned were merged into a single one in larger and more commodious premises known as the old arc light station, owned by the company and unoccupied at that time. Some additional tools were provided and a foreman competent to superintend any electrical and mechanical work that might be required, was put in charge.

17. For several reasons it was deemed advisable to maintain the arc light service as a department entirely separate from the other branches of the business; for instance, the hours of lighting are limited, and the men connected with this service in most cases have no connection with the other departments. No changes were made in this station beyond the addition of a 60 light Westinghouse arc light machine, in order to increase the reserve and decrease the liability of impaired service from burn-outs, etc.

18. Each circuit is usually run independently from two generators, of a capacity of thirty-five and twenty-five lights respectively, in series.

19. Three patrolmen drive through the streets of the city during lighting hours starting up lamps that have gone out and reporting every morning all lamps out, or requiring the attention of the repairer, as well as cases of improper carboning, etc.

20. These patrolmen also answer all fire alarms during lighting hours, and remain on hand at fires in order to cut wires, if necessary, and perform any other duties which may suggest themselves in the interests of the company. The daily reports of these patrolmen are posted in a book kept for that purpose in which the history of any particular lamp in the service can be read at a glance.

21. In the attempt to consolidate the two systems of incandescent lighting it soon became evident that all the feeders must be concentrated at one power house, in order that one station only need be kept running during daylight, and water power being cheaper than coal, that station which had the largest water wheel equipment was the most suitable for a central station. The Standard Electric Company's large and commodious power house best answered the requirements and was selected as the central or distributing station and the alternators in the other stations were connected, each by a pair of wires, to a central switchboard in this station.

22. In the steam station a 500 volt, direct current, compound wound generator of 250 h. p. was installed as a part of the power system, to take the place of the 500 volt U. S. machine above referred to.

23. The stations a, b and c, of the Chaudiere Company,

having become sub-stations, a switchboard panel for each generator was provided in every station. This panel is made of marble set into an iron frame. Each panel contains a T. H. voltmeter connected by pressure wires with the switchboard in the central station, a T. H. ampere meter, alternator field rehostat, main combined switch and cutout, and exciter combined switch and cutout. As these cutouts or fuse blocks, that serve at the same time the purposes of a switch, are also used in the central switchboard, they may be described here.

24. They consist of a block of lignum-vitae hollowed in the centre so as to form a chamber, air tight but for a small aperture in one side. This chamber contains a fuse of aluminum alloy. The terminals are outside this chamber and fully protected. When a fuse blows the sudden expansion of the air contained in the chamber causes a sudden air blast through the aperture effectually breaking the arc. The terminals extend outward in the form of metallic plugs, which may be inserted in or withdrawn from spring receptacles set in the switchboard. There are no metal parts exposed on the face of these panels from which there is danger of receiving a shock or getting burned.

25. Each generator in the steam station is excited by a separate machine, but each of the exciters is of sufficient capacity to excite any two of the generators.

26. Even the most approved water wheel governors are not sufficiently sensitive or rapid in their action to maintain constant wheel speed under large or sudden changes of load and the speed of water wheels on power service varies to a considerable extent. To prevent wheels racing when a heavy circuit is opened, hand levers were arranged to throw the governor into faster gear with the gate, so as to close it in a few seconds. While this was an excellent feature as a preventive of accidents, a remedy for the more or less continuous variations of voltage in the circuits had to be found, and for this purpose a separate turbine was set up to run dynamos capable of exciting the fields of not only all the direct current generators, but also those of the alternators in this station. The fields will now remain constant, no matter how the speed may vary and the fluctuations of E. M. F. will be materially reduced.

27. The machines used as exciters are one of the 250 volt D. C. generators (run at 125 volts) for the alternators, and two of the 550 volt U. S. machines before referred to (run on a three wire system), for the 250 and 500 volt generators.

28. These exciters are also used to directly supply the motor circuits on Sundays when the load is very light, and the motor wheel which has run day and night during the week is shut down.

29. Each D. C. generator is supplied with a double-throw switch by means of which its fields may be connected either with the separate exciter or with its own armature. Alternators may also be excited by the common exciter or independently, the change being made through the switchboard.

30. Each of the three companies had pole lines in the same

districts; in many cases both sides of a street were occupied by them. The number of poles to be maintained was reduced by placing all the wires running on a street on the best pole line and discarding the other. The lighting districts that were occupied by two different systems were divided in two, so that, while the number of feeders was actually reduced by three pairs the number of distribution centres was doubled and the line loss between them and the converters was correspondingly decreased.

31. The mains running through contiguous districts are made to overlap, so that all public buildings such as churches, theatres, halls and hotels have their lights divided between at least two separate circuits and converters. This makes it almost impossible, in case of accident, for all the lights to be out at one time.

32. The size of feeder units had been kept down within the capacity of the smallest generator, but it was found advisable to increase the units for the present to 1,000 and 1,500 lights, which seemed to best fit our generator units.

33. Eight circuit feeders were calculated for an ultimate load of 1,500 lights, and ten for 2,000 lights; this left some margin for extensions.

34. This change made it necessary to run the 750 light machines in pairs as a 1,500 light unit.

35. First parallel running was tried but it was found that the idle currents were considerable at times and this method of running was abandoned. Two of the generators were then mounted on iron girders set very accurately so as to approximate a solid iron base, and flanged pulleys were put on the shafts and bolted together. These generators could thus be driven as a single machine. The armatures were connected in multiple. If this arrangement proves satisfactory, from a mechanical point of view, the other generators in this station will be similarly coupled.

36. It is necessary to the proper working of a lighting and power service, that the losses in the different parts of each circuit should be predetermined and unchangeable. In order to better obtain this result a series of official wiring tables were issued by the company, covering interior wiring services, mains, feeders, etc., together with such printed directions as would secure uniformity in the manner of using the tables, a thing much to be desired but not always obtained. The losses to be 10% in feeders, 2% in mains, 1% in services and 2% inside buildings calculated.

37. It was also necessary for the convenient working of the lighting system that a uniform voltage should be maintained on all mains, and 1040 volts was decided upon; it was also decided, however, that 50 volt lamps would be used, experience having taught us that lamps of medium efficiency when run by water power gave the best results for customers and company, when burned somewhat above their normal voltage.

38. The public has come to expect a great deal of light from a 16 candle power lamp. If the lamp is good and the efficiency 3½

watts per candle or lower, it will maintain its candle-power for a considerable time when overrun by four per cent.

39. Converters of 100 light capacity have been introduced wherever the business was sufficiently bunched up, displacing the smaller ones which are used in the districts of more scattered lighting. No doubt still larger ones will be used in time.

40. The compensator system of regulation was adopted in preference to the feeder and pressure wire system. We still have the feeders, and the compensators take care of all the losses between the dynamo and the lamp, while the pressure wires lose their usefulness at the distribution point, although the losses between that point and the lamps may be considerable in some cases.

41. Each circuit is provided with at least three non-arcing lightning arresters, one at the station, one at the point of distribution and one or more at the distant ends of the mains. These are carefully grounded, the ground wires being riveted to street railway rails whenever possible.

42. A Bristol recording voltmeter, set up in a case convenient for carrying about, is used to adjust the compensators. The voltmeter is left at some point of the circuit to be adjusted, for twenty-four hours. This is repeated at different points of the same circuit. The adjustments should be checked once a month.

43. The main switchboard situated in the central station consists of thirty-four marble panels set side by side in a framework of angle steel fastened to the stonework of the building. This frame stands at least six feet from the wall and is supported by soft rubber discs set into iron rings fastened to the floor. These discs have the effect of taking up the vibrations of the floor, and prevent their being communicated to the instruments above. The switchboard is 57 feet long and nine feet in height.

44. There are eight dynamo panels similar to those in the other stations and already described, six for the alternators in this building and two spare ones.

45. Five motor panels that contain Weston illuminated dial voltmeter, Weston edgewise ampere meters, Westinghouse circuit breakers, ground detector, and jaw switches, through which all the motor circuits and D. C. generators are interchangeable.

46. The twenty feeder panels contain Westinghouse pendulum voltmeters, ampere meters and compensators, throw-over switches and panels for plug and cable connection with twelve pairs of bus bars and combination switches and fuse blocks, as already described.

47. These twenty panels are divided into two sections of ten between which a special panel is set up, containing a clock, a ground detector and switch, and other special devices.

48. Directly in front of each section of feeder panels and four feet away from them stands a table made up of an iron frame work with sides of wire netting and plate glass top set in a

polished brass frame. Each of these tables contain ten regulators or "boosters" with a range of 20°/₀ up or down. Each circuit can thus be regulated independently.

49. The attendant at this switchboard controls the whole system. He is also in communication with the attendants at sub-stations and the station superintendent's residence by a private telephone line.

50. For economy in line construction it was decided not to extend the 250 volt motor system except for units of one h. p. or less, and to merge it and the 500 volt service into one single three wire distribution. The 100 h. p. motor in the flour mill is, however, on a separate circuit and may, if desired, be run independently of the others. The three wire system is supplied by two of the 250 volt 60 h. p. generators in series, and the 500 volt 250 h. p. generator connected to the + and − wires. The brushes of the 250 volt machines on the + side and the + brush of the 500 volt machine, may be connected together for equalizing purposes. All the D. C. generators are interchangeable through the switchboard.

51. It was found necessary to almost completely reconstruct the motor circuits. Four pairs of No. 0000 feeders were strung up. As the joints in wire of that size are extremely unsightly a portable welder was constructed for welding the lengths of wire together. A large regulator core was fitted with a primary coil of 388 turns and a secondary coil of a single turn made up of 12 No. 0000 wires upon the ends of which massive metal jaws were shrunk. These jaws normally stand about four inches apart, but may be pressed closer together by an insulating clamp and screw, the elasticity of the secondary coil causing the jaws to resume their normal position when released. The current is regulated by a T. H. reactive coil. This apparatus may be attached to any converter on the line as required.

52. Several of the U. S. dynamos in use for lighting up to 1889 have been put in service as motors, two of them running elevators very successfully.

53. The company has lately made what is believed to be an innovation in providing in its office, which is open day and night, a locker with a glass front in which are displayed rubber coats, gloves and shoes. This in addition to the rubber gloves regularly supplied to the linemen. The key of this locker hangs within a little box behind a glass which is to be broken, in case of accident, by anyone requiring the clothing.

egula-
Each

whole
nts at
by a

to ex-
p. or
single
hill is,
e run
pplied
e 500
The
brush
ualiz-
eable

struct
trung
tly a
f wire
coil
up of
jaws
nches
lamp
jaws
ent is
y be

1889
leva-

e an
ight,
oats,
loves
angs
case